



# Recovery of a Bryophyte Community on Hurricane Island, Maine

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## Abstract

Recovery of a bryophyte community on an artificially denuded granite ledge was monitored for 4 years on Hurricane Island, Maine. Predominant bryophyte species were *Dicranum polysetum*, *Polytrichum juniperinum*, *Dicranum flagellare*, *Polytrichum piliferum*, and *Dicranum fuscescens*. Site factors such as nutrient supply, moisture, and availability of reproductive material were considered in relation to bryophyte growth to assess the ability of a specific island plant community to recover from a major disturbance. Recovery of the bryophyte community was rapid, with 60 percent bryophyte coverage over a bare rock surface by the end of the study. There was a strong relationship between the amount of needlefall from a nearby spruce-fir stand and the percent area coverage of bryophyte species.

Plant communities and growing conditions of the Penobscot Islands off the coast of Maine have been compared to those of alpine regions (Hill 1919; 1923) and often are classed as boreal-subarctic, alpine, or sub-alpine. Considerable research has documented the recovery of damaged plant communities in alpine and arctic regions (Babb and Bliss 1974; Saville 1972; Johnson and Van Klevé 1976) and in inland temperate forests (Studlar 1980; 1983), but there has been little quantitative research on plant recovery after major disturbances on Maine islands. There are many similarities between alpine and island plant communities, but the parameters affecting recovery rates undoubtedly differ between the two ecosystems.

Base-line information is essential in determining the ability of island vegetation to withstand and recover from past and present patterns of use. Such information can be used as a basis for further study and comparison and to evaluate current and proposed use levels on Maine's coastal islands.

This study was designed to monitor bryophyte recovery on a bare granite ledge after the preexisting bryophyte layer had been removed. The bryophyte community was predominantly *Polytrichum* spp. and *Dicranum* spp. The specific objectives of the study were to measure the rate of recovery of a bryophyte community over a period of 4 years, and to observe the effects of environmental factors on subsequent vegetation growth.

## Study Area

Hurricane Island is located off the southwest coast of Vinalhaven Island in Penobscot Bay, Maine. It is a dome-shaped island, approximately 140 acres, and formed of fine-textured granite bedrock. Although some parts of the island are overlain by glacial till, for the most part soils consist of accumulations of organic material of varying depths. The soils of the Maine islands are young, shallow-to-bedrock, acidic, podsolized mor soils (Davis 1966). Mor is defined as "a humus layer of unincorporated organic matter, usually matted or compacted or

both, distinctly delimited from the mineral soil" (Heiberg and Chandler 1941).

The maritime climate of the Penobscot Bay islands was described by Davis (1966) and Conkling (1981). Two major influences that affect the coastal climate are: (1) the Nova Scotia Current, an offshoot of the Labrador Current originating in polar regions which influences air temperature; and (2) recurrent fog which characterizes the Maine coast during the summer months. The combination of cool temperatures and relatively high humidity produces a flora with both temperate and boreal characteristics (Hill 1923).

A good account of the history of Hurricane Island was given by McLane (1982). The most extensive human disturbance in the island's recorded history was an intensive granite quarrying operation that took place between 1870 and 1915. Its influence on island topography and the subsequent transitional vegetation still are apparent. The island currently is being leased by the Hurricane Island Outward Bound School and is used as a base for the school's outdoor education programs.

The site chosen for study is located on a granite ledge on the northwest side of Hurricane Island. The ledge is 15 m wide and 10 m long and is surrounded by spruce-fir forest. The most common tree species are balsam fir and red spruce. The slope faces northwest with a gradient of 10 to 20 percent. This site was selected for study because:

1. The original bryophyte layer recently had been removed from the ledge, providing a unique opportunity to observe successional

recovery of a bryophyte community on a bare rock surface.

2. Hurricane Island is typical of many coastal islands in its vegetation, climate, geology, and history.

## Methods

The original bryophyte mat was removed from the ledge by hand in July and August of 1980 and used to rejuvenate trampled ground in another part of the island. Random measurements of erect stem height (soil to shoot tip) were taken before moss removal. Stem height of the initial moss carpet ranged from 5 to 10 cm. Species were identified both in the field and in the laboratory. Nomenclature for bryophyte species is based on Crum (1973).

The mat comprised the following species (in order of frequency): *Dicranum polysetum*, *Polytrichum juniperinum*, *Dicranum flagellare*, *Polytrichum piliferum*, and *Dicranum fuscescens*. Species found less frequently (in some cases only a few stems in a single sample) were *Pohlia nutans*, *Dicranum viride*, *Pleurozium schreberii*, *Hypnum fertile*, *Dicranum montanum*, and *Dicranum spurium*. Lichens (predominantly *Cladonia* spp.) were growing at the study site and represented zero to 10 percent of the total vegetation. In this study, the dominant moss genera *Polytrichum* and *Dicranum* were given primary consideration.

*Polytrichum* or haircap mosses are generally loose- to dense-tufted plants with rigid stems and spreading leaves. These hairy-capped mosses are indicators of acid conditions and due to their robust growth form are relatively resistant to trampling damage (Studlar 1983). *Polytrichum* grow on shallow soil or rock in dry, exposed, or partially shaded sites. They are found on sunny ledges or knolls in moist woods (Crum 1973). *Polytrichum* is dioecious (male and female plants are separate) and sexual and asexual regeneration are common. Photosynthesis can occur in stem shoots and side leaves.

*Dicranum* mosses are small to large dense tomentose-tufted plants with erect stems and spreading leaves. Like *Polytrichum*, they do not change in form when dry. Some species prefer thin soils or humus over rock in semi-shaded, dry to moist woods while other species are most commonly found growing on stumps, exposed roots, and rotted logs. *Dicranum* are dioecious and produce abundant sporophytes. They can be considered functionally monoecious in that the small male plants often are found resting on the leaves of the larger female plant. This advantage favors regeneration from plant fragments as well as by spore dispersal.

The quadropod photographic technique described by McBride and Leonard (1982) was used to monitor the rate of bryophyte recovery. Four transects of varying length were laid out on the granite ledge. To mark each transect line, a tape was stretched between designated tagged trees located on opposite sides of the ledge. Quadropod plots were placed adjacent to each other at intervals of 1 m along the transects. Nine plots were monitored throughout the study. Each plot was photographed four times over the study period; photo dates were 9/19/80, 7/15/81, 8/16/82, and 7/25/83.

The photographs were analyzed in the lab in the following manner: The slides were projected onto an audioviewer projector screen. An acetate overlay with an outline of the quadropod base was placed over the image. Boundaries of bryophyte coverage, bare rock, mor, and litter were traced on it. The outlines were transferred from the acetate to graph paper and area coverage was measured with a planimeter. In this case, litter is predominantly spruce needles with some twigs and deciduous leaves. Moss and lichens were measured as a single cover type. The reasons for this were:

1. The species that were removed originally and that reappeared during recovery were intermingled to a degree that made accurate measurement of individual species difficult.

2. We were primarily interested in the rate of recovery of the plant community as a whole rather than recovery rates of individual species.

## Results and Discussion

The study plots were analyzed and graphed separately to observe whether plant recovery rates were influenced by plot location. There was no perceptible correlation. However, all graphs showed a strong correlation between area cover of mor plus litter and moss. The similarity between plot graphs prompted us to group the data for a single set of results. Figure 1 shows the grouped percent area coverage data of bryophytes, mor, and bare rock over 4 years. Two trends are apparent from Figure 1:

1. There is an inverse relationship between the percent coverages of bryophytes and mor plus litter. This suggests that the recovery of the bryophyte community is directly related to the percent coverage of mor and litter.
2. Recovery is rapid. The rock surfaces in the plots were 60 percent covered by bryophytes after 4 years.

What follows is a discussion of factors that may have influenced or contributed to the recovery of the bryophyte community.

Plant production in alpine, arctic, and boreal regions most often is limited by nutrient supply or water-related factors such as precipitation, evaporation, and groundwater supply (Bliss 1971; Saville 1972; Busby et al. 1978). The degree to which these factors limit plant growth varies between ecosystems and more particularly by microsite. In our study, moisture, nutrient supply, and regenerative ability appeared to be adequate, resulting in a surprisingly rapid recovery of the plant community.

Mean annual precipitation in the Penobscot Bay region is 113 cm. During the drier months of July and August, the lack of precipitation often

is compensated for by fog. In addition, leafdrip and surface runoff contributed to the total water supply at the study site. The moisture regime of this island environment appears favorable for bryophyte growth and recovery.

A major nutrient source and source of organic matter was needle-fall from the adjacent spruce and fir trees. This also provided a substrate on which new vegetation could become established. Moisture and temperature conditions favored at least partial decomposition of the needles, promoting the plant growth to mor plus litter relationship (Fig. 1). Leach-

ates from the surrounding canopy and sea salt to a lesser extent also may have been part of the nutrient supply. In some cases, litter is a major limiting factor to moss growth (Bard 1965). In our study, the mor and litter layers on the ledge during the recovery period did not exceed a depth of 3 to 5 cm. Rather than inhibiting bryophyte growth, a substrate was provided for relatively rapid recovery.

The growth forms of the dominant species in each genera favored both sexual and asexual regeneration. Removal of the original bryophyte mat was relatively complete; however, some small moss fragments and bits

of humus remained on the ledge. Asexual regeneration from such fragments after a disturbance was observed for *Polytrichum* by Studlar (1983), and it was expected that this form of regeneration-for both *Polytrichum* and *Dicranum* was prevalent at the study site.

Thick carpets of moss similar to the bryophyte layer originally growing on the granite ledge were found growing in areas adjacent to the study site. The availability of reproductive material from such areas and small dispersal distances allow the possibility of sexual reproduction as well.

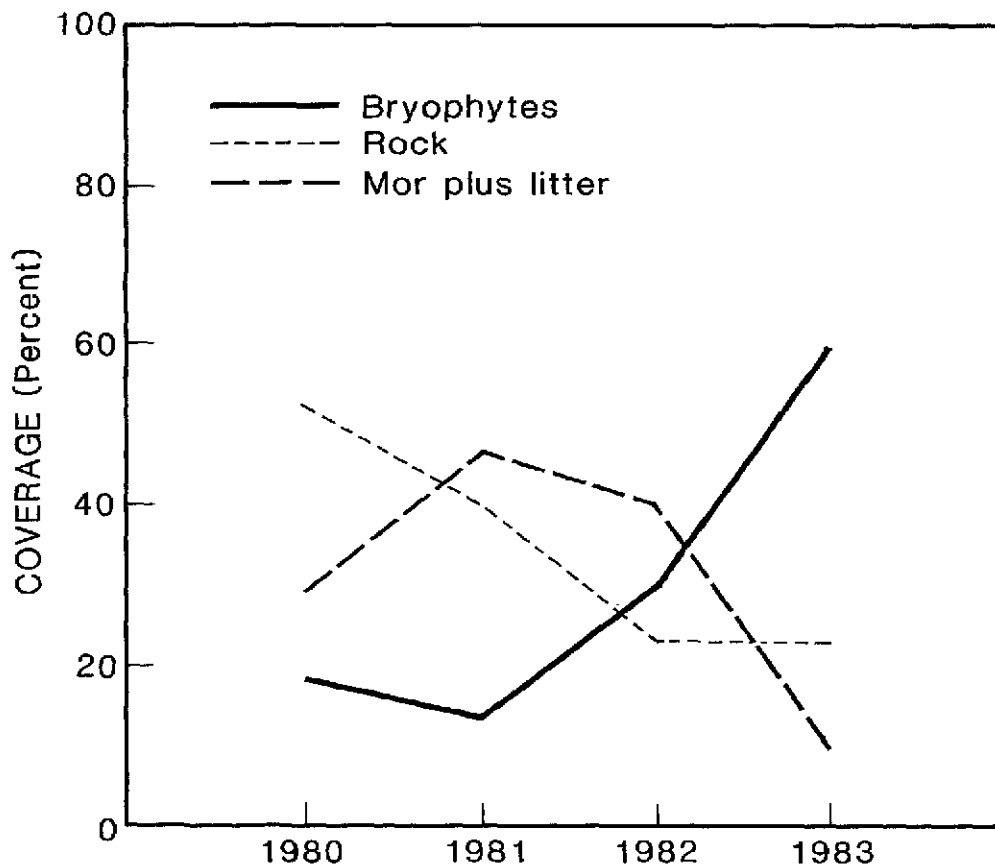


Figure 1.—Bryophyte recovery on Hurricane Island, Maine.

The sampling procedure for species identification was not comprehensive enough to relate changes in species composition and diversity to the disturbance or recovery time. However, it is expected that initial species diversity would be relatively high during early recolonization due to reduced competition from dominant species. But with progression of the recovery period, it is expected that species composition would approach that of the predisturbance community.

Studlar (1983) found that recovery rates for *Polytrichum* are rapid (approximately 80 percent after 1 year) at high trampling levels (4,200 tramples) in a cool, humid, species-rich environment. Other studies in less favorable environments—alpine and bog—have shown slow bryophyte recovery rates (from 8 years to no observable recovery) (Willard and Marr 1971; Bayfield 1979). In a study monitoring *Dicranum* recovery following low-level trampling (350 tramples) in a pine forest, Rogova (1976) observed that the population was “unrestored” after 1 year.

Although the degree and type of disturbance varies between studies, recovery of the bryophyte community observed in this study was comparatively rapid and appears to be promoted by a combination of environmental factors. The recovery rate appears to be directly related to the amount of mor plus litter on the granite ledge. Therefore, the proximity of the site to a source of organic material, in this case a stand of spruce and fir trees, is perhaps the most important factor influencing the rate of recovery at this island site. We hypothesize that the ledge will have close to 100 percent bryophyte coverage in 1 to 3 years.

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